Systematic Analysis of Facial Recognition Improvements in Multiple FRGC Challenges

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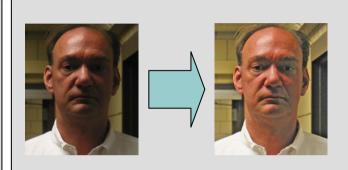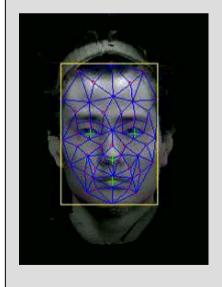Viisage Technology

FRGC/ICE Workshop, March 22-23, 2006

Outline

- **Scanner Characteristics & Illumination Correction**
- **3D Face Recognition**
- **High Resolution Data**
- **Overview to all Challenges**
- **Conclusions & Outlook**
- **References**

2

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→ **Scanner Characteristics & Illumination Correction**

3

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Image Preprocessing
Color Conversation (Minolta Scanner)

Observations

➢ R, G, B, and 3D scan not recorded at same time resulting in motion artifacts (e.g. pose correction)

➢ G, B rather dark

Corrective Actions

➢ Modification of standard RGB to grey conversion, i.e. only use of R channel

➢ Application of illumination correction algorithms

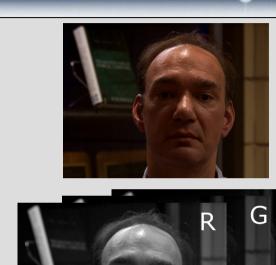➢ Mixed dataset experiments (Exp. 5 & 6) must be handled separately

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Image Preprocessing - Results

Results

- Exp. 3t: Accuracy on single channels – R>G>B

- Exp. 5: Some overexposure on red channel of **controlled** dataset, R only is worse than RGB to grey conversion [(2R+7G+1B)/10]

- Exp. 6: Underexposure in all channels of **uncontrolled** dataset, R better than RGB to grey conversion [(2R+7G+1B)/10]

	(2R+7G+1B)/10	R	G
Experiment 3	-	1.2% / 96.7%	2.7% / 92.4%
Experiment 5	4.2% / 79.3%	4.1% / 76.5%	-
Experiment 6	5.2% / 76.1%	4.4% / 77.9%	-

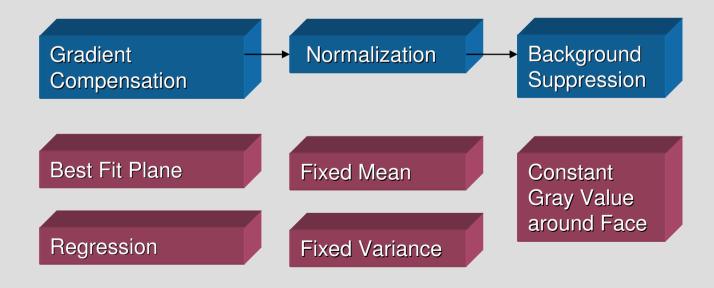*** EER / Verification@FAR 0.1%**

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Illumination Correction (I)

Regression Over Grey Level Values in Facial Area

➢ Symmetry assumption, compensates for the slant of the regression plane

➢ Standardized image to fixed mean value and fixed variance
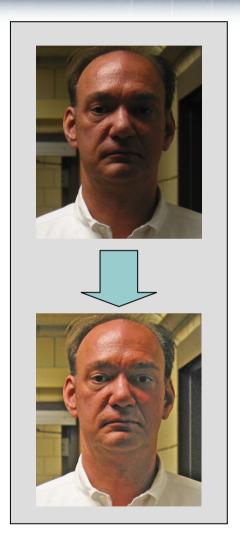
Gradient Compensation	→	Normalization	→	Background Suppression

Best Fit Plane	Fixed Mean	Constant Gray Value around Face
Regression	Fixed Variance	

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Illumination Correction (II)

Neighborhood Dependent Approaches

➢ Cooperation with Prof. Vijayan Asari, Old Dominion University

➢ Two approaches evaluated and optimized

  ▪ HPSRR [Asari, Seow, 2004]

  ▪ INDANE [Tao, Asari, 2004]

Experimental Setup

➢ Subset of FRGC Experiment 4

  ➢ Gallery: 466 controlled images

  ➢ Probe: 958 uncontrolled images
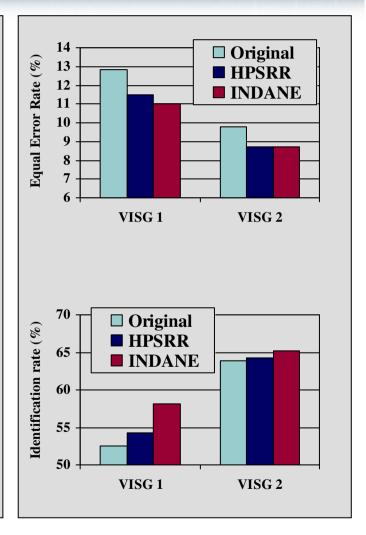
  ➢ Training: 400 controlled, 400 uncontrolled images

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Experiments & Results

➢ ## Evaluation Methods

- ▪ Two different recognition engines
- ▪ VISG 1: FaceTOOLS 3.2 (2004)
- ▪ VISG 2: Viisage's Lab engine (2004)
- ▪ Enhanced images are used as input to recognition engine
- ▪ Verification and identification scenario

➢ ## Results

- ▪ Both illumination correction methods improves Viisage's FR accuracy
- ▪ INDANE better than HPSRR (HPSRR annihilates small features)
- ▪ Improvement higher with VISG1 (VISG2 already contains regression based illumination correction)

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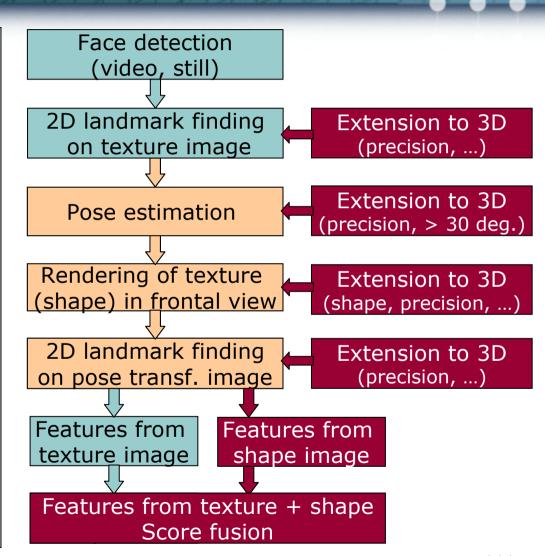
→ 3D Facial Recognition

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Fusion Strategies for 2D/3D Algorithms

Fusion on algorithmic level

➢ Landmark finding (2D, 3D)

➢ Pose estimation (2D, 3D)

➢ Pose correction (2D, 3D)

➢ …

Fusion on score level

➢ Shape and texture yield independent scores and quality (confidence)

➢ Fusion of scores

Face detection (video, still)

2D landmark finding on texture image ← Extension to 3D (precision, …)

Pose estimation ← Extension to 3D (precision, > 30 deg.)

Rendering of texture (shape) in frontal view ← Extension to 3D (shape, precision, …)

2D landmark finding on pose transf. image ← Extension to 3D (precision, …)

Features from texture image

Features from shape image

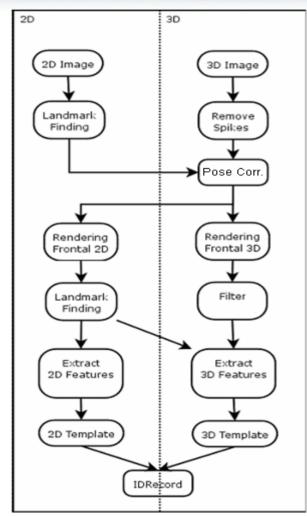Features from texture + shape Score fusion

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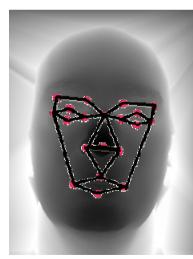
Viisage's 3D Approach (DICAR)

Foundation – HGM

➢ Graph is automatically located to landmarks

➢ Optimized features are extracted at the landmark positions -> facial template

➢ Correlation in feature space determines the similarity between faces

Extension to 3D

➢ Extension from texture to depth images

➢ Additional feature extraction on surface data

➢ Fusion of texture and shape results on score level

Results of Score Fusion

- 2D landmark finding on texture image
- Features from texture image
- Features from shape image
- Score level fusion

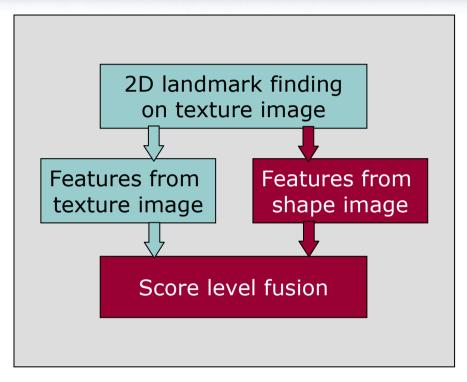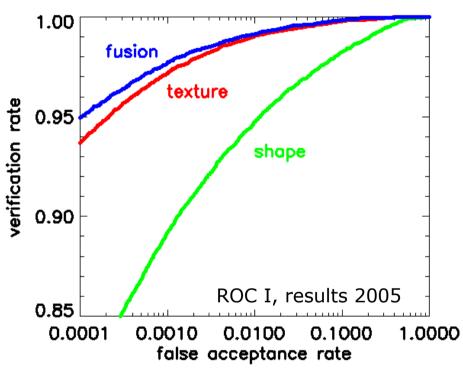ROC I, results 2005

fusion
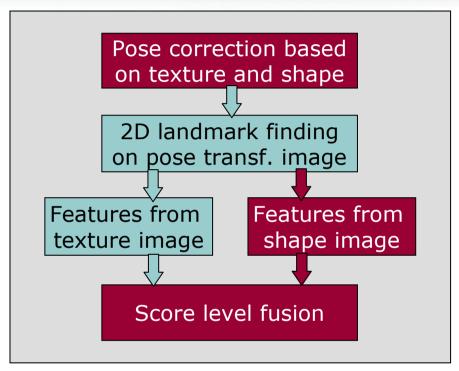texture
shape

verification rate
false acceptance rate
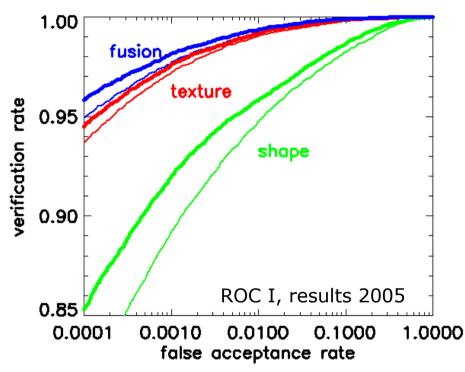
➢ Texture strongly outperforms shape, even in spite of unbalanced illumination

➢ Score level fusion yields the best results

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Fusion of Algorithms and Scores

Flowchart:
- Pose correction based on texture and shape
- 2D landmark finding on pose transf. image
- Features from texture image
- Features from shape image
- Score level fusion

ROC I, results 2005 — verification rate vs. false acceptance rate (fusion, texture, shape)

➢ Pose correction yields further improvement in both modalities and after fusion

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3D Results on Actual Engine

Results of 2005 are confirmed

- ➢ 2D HGM engine only performs at level of 97–98% correct verification rate @ FAR of 0.1%
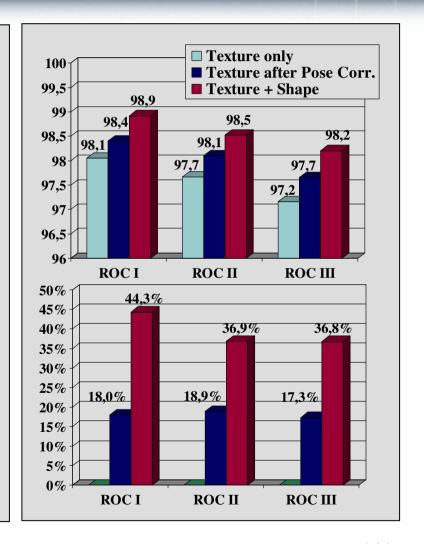
- ➢ Pose correction using 3D shape improves verification rate by approx. 18 % in comparison to 2D engine

- ➢ Combined pose correction, HGM on shape and score fusion of shape and texture improves verification rate by 37-44% in comparison to 2D engine

- ➢ Absolute differences are less than 1% in verification rate

Chart legend:
- Texture only
- Texture after Pose Corr.
- Texture + Shape

Top chart values (ROC I / ROC II / ROC III):
- ROC I: 98,1 — 98,4 — 98,9
- ROC II: 97,7 — 98,1 — 98,5
- ROC III: 97,2 — 97,7 — 98,2

Bottom chart values:
- ROC I: 18,0% — 44,3%
- ROC II: 18,9% — 36,9%
- ROC III: 17,3% — 36,8%

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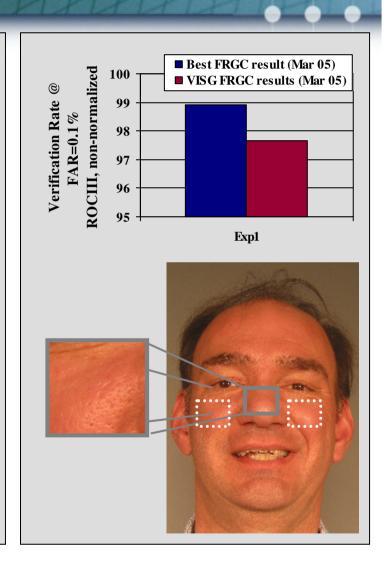→ **High Resolution Data**

15

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High Resolution Data

Motivation

- Analysis of FRGC results (2005)

Solution

- Correlation based method to exploit additional information in high resolution images
- Selection of appropriate areas, where facial micro features are invariant to pose, illumination and expression
- Fully integrated into Viisage's core FR engine

  - Landmark/region finding
  - Score fusion HGM/Facial Micro Features

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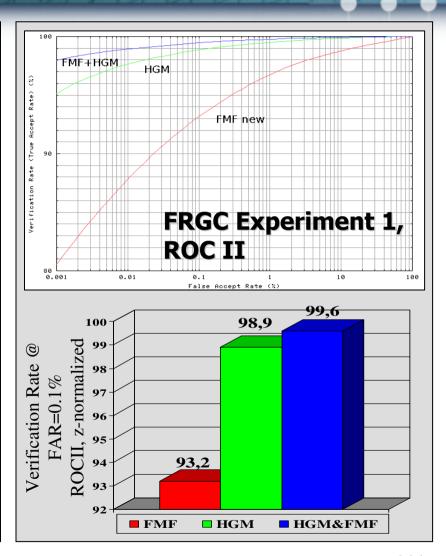
Facial Micro Features (FMF)

Results

➢ Successfully tested on multiple data sets (e.g., FRGC, FERET)

➢ Significant improvement of accuracy on high resolution images (FRGC experiment #1)

➢ Unchanged accuracy on insufficient images

➢ Low matching speed for large scale tests -> hierarchical matching implemented

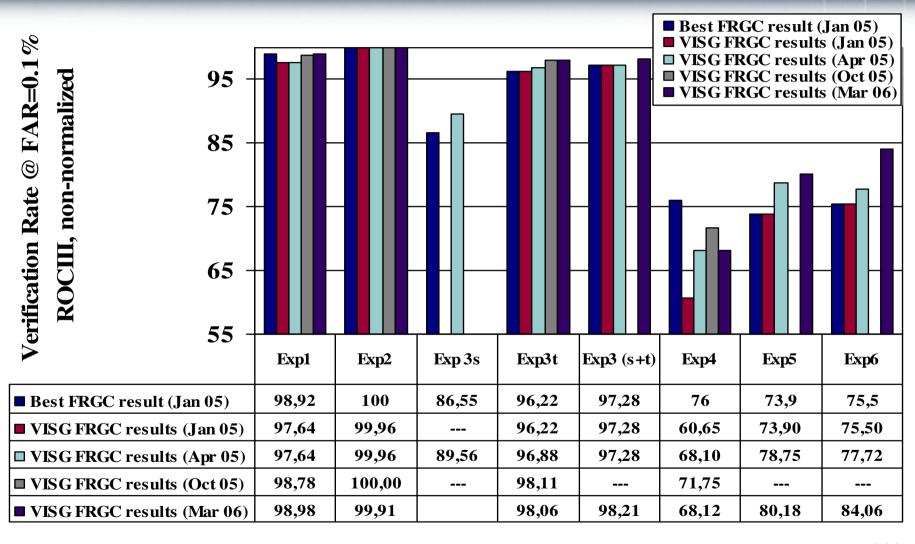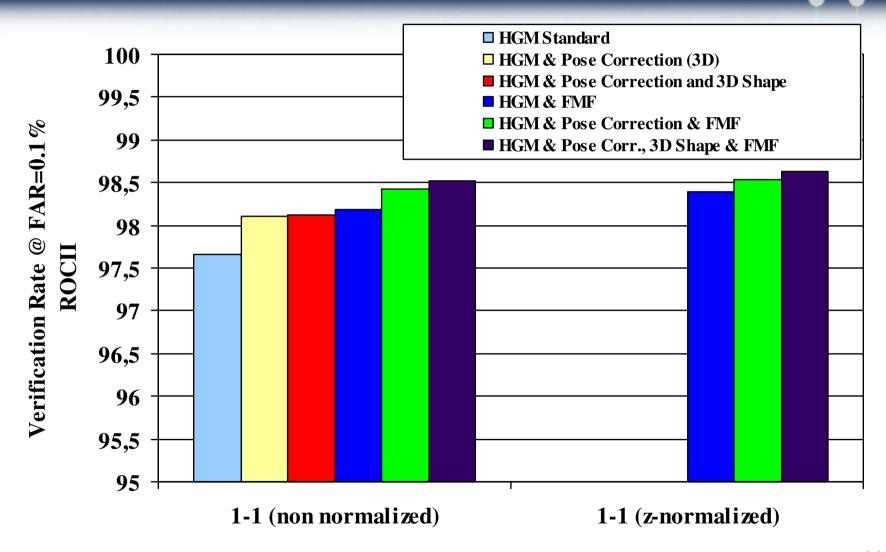➢ Small additional template size (~3kB)

FRGC Experiment 1, ROC II

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→ **Overview to all Challenges**

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Evolution of FR Performance (FRGC data)

Verification Rate @ FAR=0.1% ROCIII, non-normalized

Legend:
- Best FRGC result (Jan 05)
- VISG FRGC results (Jan 05)
- VISG FRGC results (Apr 05)
- VISG FRGC results (Oct 05)
- VISG FRGC results (Mar 06)

	Exp1	Exp2	Exp 3s	Exp3t	Exp3 (s+t)	Exp4	Exp5	Exp6
Best FRGC result (Jan 05)	98,92	100	86,55	96,22	97,28	76	73,9	75,5
VISG FRGC results (Jan 05)	97,64	99,96	---	96,22	97,28	60,65	73,90	75,50
VISG FRGC results (Apr 05)	97,64	99,96	89,56	96,88	97,28	68,10	78,75	77,72
VISG FRGC results (Oct 05)	98,78	100,00	---	98,11	---	71,75	---	---
VISG FRGC results (Mar 06)	98,98	99,91		98,06	98,21	68,12	80,18	84,06

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3D vs. Micro Features on Exp. 3

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→ **Conclusions & Outlook**

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Conclusions and Outlook

Summary

- ✓ Illumination correction greatly improves recognition on uncontrolled images
- ✓ High resolution works well for cooperative scenarios
- ✓ High resolution adds more than 3D
- ✓ We used a general purpose FR system in contrast to prior submissions

Outlook

- ✓ **FRGC** provided a cornerstone to improve FR systematically
- ✓ **FRGC** focused on specific aspects (high resolution, 3D)
- ✓ There are scenarios like low resolution, images with pose , and video processing that have been left untouched
- ✓ **FRGC II** may focus on those
- ✓ Thanks to Jonathon Philips and TSWG

- ✓ **Thanks** to all people, that contributed to the collection of datasets either with their faces or their heads.

22

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THANK YOU!

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